Designation: D543 – 06

StandardPractices for Evaluating the Resistance of Plastics to Chemical Reagents[1]

This standard is issued under the fixed designation D543; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 These practices cover the evaluation of all plastic materials including cast, hot-molded, cold-molded, laminated resinous products, and sheet materials for resistance to chemical reagents. These practices include provisions for reporting changes in weight, dimensions, appearance, and strength properties. Standard reagents are specified to establish results on a comparable basis. Provisions are made for various exposure times, stress conditions, and exposure to reagents at elevated temperatures. The type of conditioning (immersion or wet patch) depends upon the end-use of the material. If used as a container or transfer line, specimens should be immersed. If the material will only see short exposures or will be used in close proximity and reagent may splash or spill on the material, the wet patch method of applying reagent should be used.

1.2 The effect of chemical reagents on other properties shall be determined by making measurements on standard specimens for such tests before and after immersion or stress, or both, if so tested.

1.3 The values stated in SI units are to be regarded as standard. The values given in brackets are for information only.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* Specific hazards statements are given in Section 7.

NOTE 1—This standard and ISO 22088 Part 3 address the same subject matter, but differ in technical content (and the results cannot be directly compared between the two test methods).

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D13 Specification for Spirits of Turpentine
D396 Specification for Fuel Oils
D618 Practice for Conditioning Plastics for Testing
D883 Terminology Relating to Plastics
D1040 Specification for Uninhibited Mineral Insulating Oil for Use in Transformers and in Oil Circuit Breakers (Withdrawn 1980)[3]
D1898 Practice for Sampling of Plastics (Withdrawn 1998)[3]
D5947 Test Methods for Physical Dimensions of Solid Plastics Specimens

2.2 *Military Specifications:*[4]

MIL-A-11755 Antifreeze, Arctic-Type
MIL-A-46153 Antifreeze, Ethylene Glycol, Inhibited, Heavy Duty, Single Package
MIL-C-372 Cleaning Compound, Solvent (For Bore of Small Arms and Automatic Aircraft Weapons)
MIL-D-12468 Decontaminating Agent, STB
MIL-D-50030 Decontaminating Agent, DS2
MIL-F-46162 Fuel, Diesel, Referee Grade
MIL-G-5572 Gasoline, Aviation, Grades 80/87, 100/130, 115/145
MIL-H-5606 Hydraulic Fluid, Petroleum Base, Aircraft, Missiles, and Ordinance
MIL-H-6083 Hydraulic Fluid, Petroleum Base, for Preservation and Operation
MIL-H-83283 Hydraulic Fluid, Fire Resistant, Synthetic Hydrocarbon Base, Aircraft

[1] These practices are under the jurisdiction of ASTM Committee D20 on Plastics and are the direct responsibility of Subcommittee D20.50 on Durability of Plastics.

Current edition approved April 1, 2006. Published June 2006. Originally approved in 1939. Last previous edition approved in 2001 as D543 - 95 (2001). DOI: 10.1520/D0543-06.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

***A Summary of Changes section appears at the end of this standard**

MIL-L-7808 Lubricating Oil, Aircraft Turbine Engine, Synthetic Base, NATO Code Number 0–148
MIL-L-14107 Lubricating Oil, Weapons, Low Temperature
MIL-L-23699 Lubricating Oil, Aircraft Turbine Engines, Synthetic Base
MIL-L-46000 Lubricant, Semi-Fluid (Automatic Weapons)
MIL-T-5624 Turbine Fuel, Aviation, Grades JP-4 and JP-5
MIL-T-83133 Turbine Fuel, Aviation, Kerosene Type, Grade JP-8

2.3 *U.S. Army Regulation:*[4]
AR 70-71 Nuclear, Biological, and Chemical Contamination Survivability of Army Material

2.4 *ISO Standards:*[5]
ISO 175 Plastics—Determination of Resistance to Liquid Chemicals
ISO 22088 Part 3 Plastics—Determination of Resistance to Environmental Stress Cracking (ESC)—Bent Strip Method

3. Terminology

3.1 *Definitions*—Definitions of terms applying to these practices appear in Terminology D883.

4. Significance and Use

4.1 The limitations of the results obtained from these practices should be recognized. The choice of types and concentrations of reagents, duration of immersion or stress, or both, temperature of the test, and properties to be reported is necessarily arbitrary. The specification of these conditions provides a basis for standardization and serves as a guide to investigators wishing to compare the relative resistance of various plastics to typical chemical reagents.

4.2 Correlation of test results with the actual performance or serviceability of plastics is necessarily dependent upon the similarity between the testing and the end-use conditions. For applications involving continuous immersion, the data obtained in short-time tests are of interest only in eliminating the most unsuitable materials or indicating a probable relative order of resistance to chemical reagents.

4.3 Evaluation of plastics for special applications involving corrosive conditions should be based upon the particular reagents and concentrations to be encountered. The selection of test conditions should take into account the manner and duration of contact with reagents, the temperature of the system, applied stress, and other performance factors involved in the particular application.

5. Apparatus

5.1 *Balance*—A balance capable of weighing accurately to 0.05 % for a test specimen weighing 100 g or less, and to 0.1 % for a test specimen weighing over 100 g. Assurance that the balance meets the performance requirements should be provided by frequent checks on adjustments of zero points and sensitivity and by periodic calibration for absolute accuracy, using standard masses.

5.2 *Micrometers*—Use a suitable micrometer for measuring the dimensions of test specimens similar to that described in Test Method D5947. The micrometer should have an incremental discrimination of at least 0.025 mm [0.001 in.]. For specimens 0.100 in. thick or less, the micrometer used shall have an incremental discrimination of at least 0.0025 mm [0.0001 in.]. The micrometer must be verified using gage blocks traceable to National Institute of Standards and Technology (NIST) every 30 days minimum.

5.3 *Room,* or enclosed space capable of being maintained at the standard laboratory atmosphere of 23 ± 2°C [73.4 ± 3.6°F] and 50 ± 5 % relative humidity in accordance with Practice D618.

5.4 *Containers*—Suitable containers for submerging specimens in chemical reagents. They must be resistant to the corrosive effects of the reagents being used. Venting should be provided, especially when using volatile reagents at elevated temperatures. Tightly sealed containers are preferred for room temperature testing to minimize loss.

5.5 *Strain Jigs*—Jigs are to be capable of supplying known amounts of strain to test specimens. Fig. 1 is a side view drawing of a typical strain jig used to obtain 1.0 % strain in a 3.2 mm [0.125 in.] thick test specimen. Shown in Fig. 1 is an equation that can be used to calculate strain from known dimensions or back-calculate jig dimensions for a desired specimen strain.

5.6 *Oven or Constant Temperature Bath,* capable of maintaining temperatures within ±2°C of the specified test temperatures.

5.7 *Testing Devices*—Testing devices for determining specific strength properties of specimens before and after submersion or strain, or both, conforming to the requirements prescribed in the ASTM test methods for the specific properties being determined.

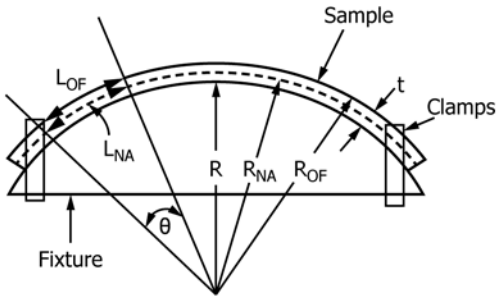
5.8 *Laboratory Hood,* or other system adequate for vapor ventilation.

6. Reagents and Materials

6.1 The following list of standard reagents is intended to be representative of the main categories of pure chemical compounds, solutions, and common industrial products. Chemicals used in these practices shall be of technical grade or greater purity. All solutions shall be made with freshly prepared distilled water. Specific concentrations are on a weight percent or specific gravity basis. Mixing instructions are based on amounts of ingredients calculated to produce 1000 mL of solution of the specified concentration.

6.2 The following list of standard reagents is not intended to preclude the use of other reagents pertinent to particular chemical resistance requirements. It is intended to standardize typical reagents, solution concentrations, and industrial products for general testing of the resistance of plastics to chemical reagents. Material specifications in which chemical resistance is indicated shall be based upon reagents and conditions

[5] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.



R = radius of jig
R_{NA} = radius of neutral axis
R_{OF} = radius of outer fiber
t = thickness of specimen

θ = arbitrary angle
L_{OF} = length of outer fiber
L_{NA} = length of neutral axis

considering a portion of test bar determined by angle θ

$$L_{NA} = R_{NA}\,\theta = (R + \tfrac{1}{2}t)\,\theta \qquad R_{NA} = R + \tfrac{1}{2}t$$

$$L_{OF} = R_{OF}\,\theta = (R + t)\,\theta \qquad R_{OF} = R + t$$

$$\Delta L = L_{OF} - L_{NA} = (R + t)\,\theta - (R + \tfrac{1}{2}t)\,\theta$$

$$\varepsilon = \frac{\Delta L}{L} = \frac{(R + t)\,\theta - (R + \tfrac{1}{2}t)\,\theta}{(R + \tfrac{1}{2}t)\,\theta}$$

$$\varepsilon = \frac{(R + t) - R + \tfrac{1}{2}t}{R + \tfrac{1}{2}t} = \frac{\tfrac{1}{2}t}{R + \tfrac{1}{2}t}$$

$$\varepsilon = \frac{1}{\frac{2R}{t} + 1} \qquad R = \frac{\left(\frac{1}{\varepsilon} - 1\right)t}{2}$$

FIG. 1 Determination of Strain Level of ESCR Fixtures

selected from those listed herein except by mutual agreement between the seller and the purchaser.

6.3 *Standard Reagents:*

6.3.1 *Acetic Acid (sp gr 1.05)*—Glacial acetic acid.

6.3.2 *Acetic Acid (5 %)*—Add 48 mL (50.5 g) of glacial acetic acid (sp gr 1.05) to 955 mL of water.

6.3.3 *Acetone.*

6.3.4 *Ammonium Hydroxide (sp gr 0.90)*—Concentrated ammonium hydroxide (NH_4OH).

6.3.5 *Ammonium Hydroxide (10 %)*—Add 375 mL (336 g) of (NH_4OH) (sp gr 0.90) to 622 mL of water.

6.3.6 *Aniline.*

6.3.7 *Benzene.*

6.3.8 *Carbon Tetrachloride.*

6.3.9 *Chromic Acid (40 %)*—Dissolve 549 g of chromic anhydride (C_rO_2) in 822 mL of water.

6.3.10 *Citric Acid (1 %)*—Dissolve 104 g of citric acid crystals in 935 mL of water.

6.3.11 *Cottonseed Oil,* edible grade.

6.3.12 *Detergent Solution, Heavy Duty (0.025 %)*—Dissolve 0.05 g of alkyl aryl sulfonate and 0.20 g of trisodium phosphate in 1000 mL of water.

6.3.13 *Diethyl Ether.*

6.3.14 *Dimethyl Formamide.*

6.3.15 *Distilled Water,* freshly prepared.

6.3.16 *Ethyl Acetate.*

6.3.17 *Ethyl Alcohol (95 %)*—Undenatured ethyl alcohol.

6.3.18 *Ethyl Alcohol (50 %)*—Add 598 mL (482 g) of 95 % undenatured ethyl alcohol to 435 mL of water.

6.3.19 *Ethylene Dichloride.*

6.3.20 *2-Ethylhexyl Sebacate.*

6.3.21 *Heptane,* commercial grade, boiling range from 90 to 100°C.

6.3.22 *Hydrochloric Acid (sp gr 1.19)*—Concentrated hydrochloric acid (HCl).

6.3.23 *Hydrochloric Acid (10 %)*—Add 239 mL (283 g) of HCl (sp gr 1.19) to 764 mL of water.

6.3.24 *Hydrofluoric Acid (40 %)*—Slowly add 748 mL (866 g) of hydrofluoric acid (52 to 55 % HF) to 293 mL of water.

6.3.25 *Hydrogen Peroxide Solution,* 28 % or USP 100 volume.

6.3.26 *Hydrogen Peroxide Solution (3 % or USP 10 volume)*—Add 98 mL (108 g) of commercial grade (100 volume or 28 %) hydrogen peroxide (H_2O_2) to 901 mL of water.

6.3.27 *Isooctane,* 2,2,4-trimethyl pentane.

6.3.28 *Kerosine*—No. 2 fuel oil, Specification D396.

6.3.29 *Methyl Alcohol.*

6.3.30 *Mineral Oil, White, USP,* sp gr 0.830 to 0.860; Saybolt at 100°F: 125 to 135 s.

6.3.31 *Nitric Acid (sp gr 1.42)*—Concentrated nitric acid (HNO_3).

6.3.32 *Nitric Acid (40 %)*—Add 500 mL (710 g) of HNO_3 (sp gr 1.42) to 535 mL of water.

6.3.33 *Nitric Acid (10 %)*—Add 108 mL (153 g) of HNO_3 (sp gr 1.42) to 901 mL of water.

6.3.34 *Oleic Acid, cP.*

6.3.35 *Olive Oil,* edible grade.

6.3.36 *Phenol Solution (5 %)*—Dissolve 47 g of carbonic acid crystals, USP, in 950 mL of water.

6.3.37 *Soap Solution (1 %)*—Dissolve dehydrated pure white soap flakes (dried 1 h at 105°C) in water.

6.3.38 *Sodium Carbonate Solution (20 %)*—Add 660 g of sodium carbonate ($Na_2{\cdot}CO_3{\cdot}10H_2O$) to 555 mL of water.

6.3.39 *Sodium Carbonate Solution (2 %)*—Add 55 g of $Na_2{\cdot}CO_3{\cdot}10H_2O$ to 964 mL of water.

6.3.40 *Sodium Chloride Solution (10 %)*—Add 107 g of sodium chloride (NaCl) to 964 mL of water.

6.3.41 *Sodium Hydroxide Solution (60 %)*—Slowly dissolve 971 g of sodium hydroxide (NaOH) in 649 mL of water.

6.3.42 *Sodium Hydroxide Solution (10 %)*—Dissolve 111 g of NaOH in 988 mL of water.

6.3.43 *Sodium Hydroxide Solution (1 %)*—Dissolve 10.1 g of NaOH in 999 mL of water.

6.3.44 *Sodium Hypochlorite Solution, National Formulary, (4 to 6 %)*—The concentration of this solution can be determined as follows: Weigh accurately in a glass-stoppered flask about 3 mL of the solution and dilute with 50 mL of water. Add 2 g of potassium iodide (KI) and 10 mL of acetic acid, and titrate the liberated iodine with 0.1 N sodium thiosulfate ($Na_2S_2O_3$), adding starch solution as the indicator. Each